

## **SECTION 16450**

### **GROUNDING**

#### **PART 1 - GENERAL**

##### **0.1 DESCRIPTION OF WORK**

- A. Work Included: This Section specifies furnishing and installing complete system neutral grounding, equipment grounding, and building structural grounding.

##### **0.2 SUBMITTALS**

- A. As-Built Drawings. Submit prior to final acceptance of the work, drawings showing complete layout of systems installed including physical location of ground rods to which connections were made.
- B. Field Quality Control Test Report. Submit reports complying with requirements of Part 3 "Field Quality Control" Article.

#### **PART 2 - PRODUCTS**

##### **0.1 BARE GROUND WIRE**

- A. Soft drawn copper, Class A or Class B stranded, meeting the requirements of ASTM B8; size in accordance with the NEC except where sizes specified herein or shown on the Contract Drawings are larger than those required by NEC; UL listed, Label A for lightning protection conductors. Grounding cable shall be continuous without joints or splices through its length.

##### **0.2 INSULATED GROUND WIRE**

- A. Copper, Class B Stranded, 600-Volt, 90 degree C, NEC type THWN; meeting requirements of AAR Specifications No. 535.2; sized as indicated; and UL listed.

##### **0.3 PRODUCTS USED FOR COPPER THERMIT WELDED CONNECTIONS**

- A. Use products for copper thermit welded connections which are the products of one manufacturer and are produced for the specific application for which they are used.

- B. Use materials and equipment which meet or exceed the applicable acquirements of the AAR Manual, Electrical Section, Section 13, Chapter 3, Part 6.
- C. Coating Materials for Thermit Welded Connections: Use black, rubber based compound coating materials, which are soft, permanently pliable, moldable, and unbacked, not less than 1/8 inch thick, with properties as follows:

Solids	100 percent
Density	12.0 pounds per gallon minimum
Penetration	90-130 ASTM D5
Water Absorption	0.10 percent maximum ASTM D570
Dielectric Strength	500 volts/mil ASTM D149
Volume Resistivity	2,000 megohms-inches ASTM D257 5,000 megohms-cm ASTM D257
Service Temperature	Minus 40 degrees to 160 degrees F.
Chemical Resistance	Melting point, none; flammability, slow burning (ASTM C653); resists alcohol, water, aqueous hydrochloride and sodium hydroxide; dissolved by carbon tetrachloride, naphtha gasoline, mineral spirits, ketones, and benzene.
Highly cohesive and Adhesive	Adheres strongly to metals and concrete and to itself.

#### **0.4 BOLTED GROUNDING CONNECTORS**

- A. For solderless type made of high strength electrical bronze with silicon bronze clamping bolts and hardware; designed such that bolts, nuts, lock washers and similar hardware which might nick or otherwise damage the ground wire will not directly contact the ground wire.

#### **0.5 GROUND BUS**

- A. 1/4 inch by 2 inch copper bus bar mounted as shown on the Contract Drawings; drilled and tapped to receive ground cable connections from the ground rod assembly and ground connections for equipment as required.

## **0.6 GROUND RODS**

- A. Medium carbon steel core, copper clad by the molten weld casting process; sizes as shown on the Contract Drawings; UL approved.

## **PART 3 - EXECUTION**

### **0.1 PREPARATION**

- A. Perform testing as specified in Part 3 "Field Quality Control" Article.

### **0.2 GENERAL GROUNDING REQUIREMENTS**

- A. General. Provide station electrical grounding complying with procedures of NEC and as indicated.
- B. Equipment Ground Conductors
  - 1. Provide each conduit entering switchgear with equipment ground conductor, colored green.
  - 2. Terminate conductor directly on ground bus for switchgear equipment housing and conduit system; do not connect equipment ground conductor to neutral bus. Additionally, do not use these conductors to carry any line-to-ground loads, such as 277 volt lighting.
  - 3. Provide feeders serving three-phase, 480 volt, or single phase, 480 volt loads with one equipment ground conductor.
- C. White Neutral Conductor. Provide each conduit feeding line-to-ground loads, such as 277 volt lighting with both an equipment ground conductor and insulated white neutral conductor.
- D. At Double-Ended Substations Serving Station Service Equipment
  - 1. Provide switchgear having neutral bus with isolating links and single ground between neutral bus and ground bus. Additionally, neutral bus shall be insulated from switchgear housing and conduits.
  - 2. Provide neutral buses and equipment ground bus bonding conductors with ground fault sensors having vector summation ground fault protection to select whether ground fault is fed from transformer "A" or transformer "B" and capable of opening appropriate breaker with shunt trip devices provided with breakers.
- E. Provide convenience outlets having ground fault circuit breakers, complying with Section 16050 - BASIC MATERIALS AND METHODS FOR ELECTRICAL WORK.

### **0.3 SYSTEM NEUTRAL GROUNDING**

- A. General. Provide three-phase alternating current secondary distribution systems wye connected with neutral grounding at the source.
  - 1. Run throughout as indicated, system neutral and ground bus and equipment ground conductor or both as indicated. Wye-connect generators and ground neutrals. On wye systems where generator neutrals are grounded at unit, to prevent improper operation of ground fault protection equipment, provide four-pole transfer switches, except at 13.8 kilovolt feeder breakers serving primaries of load center unit substations with automatic transfer accessories.
  - 2. Solidly ground neutral deriving equipment.
  - 3. Connection Secondary Wye Neutral Points.
    - a. At Equipment Described in Part 3 Article above. Connect neutral points to primary source equipment ground and where applicable secondary ground bus.
    - b. At Power Transformers and Load Centers. Provide copper conductors, sized, as indicated, but in no case smaller than that required by NEC.
    - c. At Dry-Type Transformers. Use equipment ground conductor for connection of equipment and neutral to ground system.
  - 4. Where source of power is from an electric utility company, at point of service to facility, solidly interconnect utility ground system by way of equipment ground system and where feasible building structural ground system.

### **0.4 EQUIPMENT GROUNDING**

- A. At each station and traction substation, install one-quarter inch by two inch copper ground bus continuously around inside periphery and connect to grounding electrodes at intervals as indicated. Additionally, provide same type ground bus at periphery of electrical equipment rooms and train control rooms.
- B. Alternating Current Switchgear, Switchboards and Motor Control Centers.
  - 1. Connect continuous equipment ground bus at each end by copper ground wire to building or facility ground bus.
  - 2. Provide ground wire equal in size to largest conductor in line feeding equipment, but not less than No. 6 AWG, nor larger than No. 4/0 AWG.
  - 3. Install ground wire in rigid steel conduit bonded at both ends.
- C. Wiring, Channels, Cable Trays, Metallic Conduit, Rigid Electrical Metallic Tubing, Flexible Conduits, Metallic Boxes, Panelboards, Generator Frames and Transformer Enclosures. Ground to ground bus with copper ground conductors sized as specified in the Construction Specifications.
- D. Motors, Lighting Fixtures and Equipment in Part 3 Article above.

1. Accomplish grounding with equipment ground.
2. Provide equipment ground conductor electrically and mechanically continuous from system equipment and neutral ground connection at source of supply to equipment to be grounded.

E. Building Type Conductors

1. Where conductors are installed in raceways, run equipment ground conductor for alternating current systems within raceways with circuit conductors.
2. Provide copper equipment ground conductor minimum one size smaller than phase conductors, except having minimum size of No. 12 and maximum size No. 4/0 AWG.
3. Identify equipment ground conductors with colored green type THW insulation, except where green insulation is not available on larger sizes, black colored insulation shall be used and suitably identified with green tape at each junction box or device enclosure.

F. Junction Boxes and Other Enclosures Sized Above Five Square Inches. Securely bond equipment ground conductors to enclosures utilizing equipment ground bus or lug.

## **0.5 BUILDING STRUCTURAL GROUNDING**

A. Ground Bus. Provide copper ground bus loop sized as indicated, buried to minimum depths and in accordance with details as indicated.

B. Ground Electrodes

1. Space electrodes as indicated, and connect each electrode to ground bus loop with copper conductor as indicated.
2. Provide copper-coated, high-strength steel rods conforming to ASTM B228, Grade 40HS, sizes as indicated, having threaded bronze couplings, and driven to depths indicated. Additionally, locate top of electrodes minimum depth below grade and in accordance with details as indicated.
3. Where soil conditions make it impossible to drive ground electrodes to depth indicated, provide three ground rods spaced maximum of 10 feet apart in shape of equilateral triangle and interconnected with copper ground conductor as indicated.
4. Make below-grade connections by brazing or thermite welding.

C. Steel Columns, Steel Reinforcing Bars and Other Materials.

1. Connect steel columns or steel reinforcing bars in exterior walls to ground bus loop at intervals indicated. For bare copper connections, utilize brazing or thermite welding at ground bus loop and brazing, thermite welding, or bolted pressure fitting at steel columns. Make connections at steel columns 18 inches above finished floor in web of columns.

2. Connect steel columns inside buildings to ground bus loop on each side of each building, with continuous bare copper conductor, as indicated.
  3. In buildings using materials other than steel for columns and where roof structure is steel, ground steel roof beams to ground bus loop similar to the methods described in Part 3 Articles above.
- D. Connect domestic and fire protection metallic water pipes to ground bus loop with bare copper conductor, as indicated, at a minimum of two points.
  - E. Connect medium voltage switchgear and load center equipment ground bus to ground bus loop with copper conductor, as indicated, at minimum of two points.
  - F. Connect miscellaneous metal objects, including piping, vessels, and structural shapes, within six feet of electrically-grounded metallic objects to ground system with a minimum No. 6 AWG bare copper conductor.
  - G. Where a lightning protection system is provided in the form of air terminals of non-conductive materials or in the form of metal protuberances, connect these systems to ground bus loop with copper conductors equivalent to No. 2/0 AWG copper. Provide systems designed in accordance with requirements of NFPA No. 78.

## **0.6 CONVENIENCE OUTLETS**

- A. Ground all convenience outlets in accordance with the NEC.

## **0.7 THERMIT WELDING CONNECTIONS**

- A. Connect electrical wires together, to reinforcing steel or soldier piles, as indicated, by thermit welding using the manufacturer's recommended molds and size of charges for application.
- B. Prepare the material to be welded and perform thermit welding in accordance with manufacturer's instructions.
- C. Test completed thermit welds before coating by striking with two pound hammer. If cracks develop, replace welds at no additional expense to the Authority. When required by the Engineer, test the electrical continuity of bonds.
- D. Apply coating so that it extends one inch beyond point of attachment to steel member, overlaps wire coating one inch, and provides insulation thickness equivalent to wire insulation, but not less than 1/8 inch in thickness. Do not apply coating material at ambient temperatures below 20 degrees F or above 125 degrees F. Maintain, by an approved method, curing temperature within above temperature range for at least four hours

after application of coating. Protect coating by approved means until embedment.

## **0.8 FIELD QUALITY CONTROL**

### **A. Testing Existing Grounding Systems**

1. General. Prior to installation of grounding systems specified under this Contract, test related grounding systems installed under previous or adjoining contracts to extent as indicated or specified in the Construction Specifications.
2. Test Report. Provide test report completely describing ground resistance test procedures and giving test results.
3. Ground Resistance Testing
  - a. Testing. Verify that resistance between ground and absolute earth for existing grounding systems does not exceed two ohms without benefit of chemical treatment or other artificial means, unless indicated otherwise in the Construction Specifications.

### **B. Testing Building Structural Grounding**

1. General. After installation of ground loop bus and ground electrodes, and prior to interconnection of other grounding systems perform ground resistance testing.
2. Test Report. Provide report giving results of testing procedures, which shall also include temperature, humidity, and condition of soil at time of tests.
3. Ground Resistance Testing
  - a. Test Equipment and Method. Perform testing using ground resistance direct-reading single test meter utilizing alternating current fall-of-potential method and two reference electrodes.
  - b. Test Procedure
    - 1) Orient ground electrode to be tested and two reference electrodes in straight line space minimum 50 feet apart.
    - 2) Drive two reference electrodes five feet deep.
  - c. Test Requirement or Limits. If ground resistance exceeds two ohms, install additional ground electrodes until resistance is two ohms or less.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **0.1 MEASUREMENT**

- A. Bare ground wire; insulated ground wire; ground bus; and ground rods; except ground wires run with circuit conductors; will be measured by the linear foot of each size complete in place, including thermit welding and lugs, connectors, clamps, and all other accessories and incidentals.

**0.2 PAYMENT**

- A. Grounding protection systems will be paid for at the Contract unit prices for the quantities as determined above.

**0.3 PAYMENT ITEMS**

ITEM NO.	DESCRIPTION	UNIT
1625.012	GROUNDING	LF

**END OF SECTION**